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WHAT WERE THE EFFECTS OF THE FORMATION OF THE BOREALIS BASIN, MARS?; Kenneth L. Tanaka, U.S. Geological Survey, Flagstaff, Ariz. 86001

Why study Mars' Borealis basin?

Borealis basin, in the northern hemisphere of Mars, is a vast, subcircular, lowland region that constitutes a third of the planet's surface area. The basin is several kilometers lower in elevation than much of the highland regions that characterize the remainder of the planet. The rim of the basin is seen to be intensely eroded and fractured where it is not buried by young deposits. Although Borealis is large and has been studied by many workers, the nature of its origin and its possible influence on climate and subsequent geologic structures have remained elusive problems. Some workers have thought that it formed by single or multiple impacts of asteroid-size bodies. Other workers have favored a tectonic origin, whereby the basin records a major geologic event in which the crust was lowered by overturn of material deep within the planet. Moreover, the basin provides Mars' largest sink for sedimentary materials deposited by wind and water, and it may also have contained ancient lakes or even an ocean. If large bodies of water once existed in the basin, they may have deposited thick carbonate layers that formed at the expense of carbon dioxide in the atmosphere. This atmospheric change would have reduced air temperature and pressure. Open bodies of water would have no longer been stable, and permafrost would have become more deeply entrenched in the Martian crust.

What progress has been made in the study of the Borealis basin?

The impact theories for the origin of the basin require its formation during intense bombardment (in the Early Noachian Epoch) to explain the lack of ejecta deposits and the paucity of possible ring structures observed along the Borealis rim. However, recent geologic mapping and crater-density studies, which form the basis for determining the relative ages of Martian surfaces and features, show that major erosional and structural features along the rim of the basin are Late Noachian to Early Hesperian in age. Thus the features formed after the early intense meteorite bombardment of the planet. If the features formed because of basin formation, an impact origin is ruled out. A tectonic origin, on the other hand, is compatible with a later time of formation. George McGill and Andrew Dimitriou of the University of

Massachusetts noted that volcanism over the planet peaked during the Late Noachian/Early Hesperian; they proposed that this coincidence with the timing of basin formation can be explained by a major tectonic event of global proportions.

My results complement these recent studies and conclusions. I suggest that erosional features along the basin rim formed from ground-water runoff that was initiated by tectonic lowering of the basin. The lowering caused ground water to flow from highland rocks into the basin. The variety of the resulting erosional features is astounding--they include channels of various sizes, morphologies, and tributary patterns; intensely eroded terrains made up of scattered hills and mesas; collapse features such as chaotic terrain, floor-fractured craters, pits, and troughs; and flood plains. The channels are widely accepted as having formed by runoff and sapping processes, and the eroded terrains may also have been subjected to the same processes as well as to secondary mass-wasting. The collapse features are suggestive of erosion or compaction of subsurface material, perhaps due to liquefaction and ground-water flow. These interpretations require that large tracts of highland rocks be made up of loose, fine debris that is easily eroded and transported and capable of trapping and releasing large volumes of water. Also, a few discontinuous troughs formed by collapse are found exclusively in northern latitudes (> 30° N.), where permafrost may have been deep when the troughs formed. The troughs may have been produced by tunnel erosion caused by ground-water rivers that once flowed below impermeable frozen ground.

The discharges of ground water required to produce these erosional features would have been extremely large. Although evidence for comparable discharges is not found on Earth, many similar discharges (chiefly related to tectonic events) are recorded on Mars in later time periods, and one of these discharges is similar in magnitude. No evidence of large-scale flooding prior to formation of the Borealis basin is found on the surface of Mars.

How did runoff of ground water into the Borealis basin affect Mars' climate?

Researchers are still uncertain about early atmospheric conditions on Mars. Thus the following suggestions are highly speculative.

If the early atmosphere was much richer in carbon dioxide than the present atmosphere, as many workers think, then atmospheric temperatures and pressures may

BOREALIS BASIN, MARS: Tanaka K.L.

have been higher. These conditions could have permitted the stability of large lakes or even a small ocean in the Borealis basin (particularly at lower latitudes). In turn, the open water would have facilitated relatively rapid carbonate formation. Atmospheric carbon dioxide would have been reduced, eliminating the earlier greenhouse conditions. As these changes took place, much of the equatorial surface and near-surface water would have been transferred to the polar caps. The colder temperatures would cause the permafrost zone to deepen. As a possible result, the depth of that zone today probably exceeds one kilometer all over Mars.

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